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14. ABSTRACT
To date, a total of 250 Soldiers have undergone a comprehensive human performance screening for injury prevention and optimal performance to evaluate musculoskeletal strength and flexibility, balance, VO2 max, lactate threshold, body composition, movement patterns during functional (tactical) tasks, along with nutritional screening. The data collected to date suggest that there are areas where a significant number of Soldiers could improve their physical readiness, mechanical, and nutritional preparation for tactical operations. These data will be compared to injury surveillance data to prospectively establish risk factors for injury. Based on the preliminary data, an injury prevention and performance optimization intervention is being developed to address the suboptimal biomechanical, physiological, and musculoskeletal characteristics.

15. SUBJECT TERMS
Injury prevention, performance decrement, biomechanics, musculoskeletal, physiological, nutritional

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TABLE OF CONTENTS

INTRODUCTION

The 101st Airborne/Air Assault Injury Prevention and Performance Optimization Program is a joint research initiative between the University of Pittsburgh, Departments of Sports Medicine and Nutrition and Orthopaedic Surgery and the Division Command and Division Surgeon of the US Army 101st at Fort Campbell. This project is funded by the United States Department of Defense and is under the auspices of US Army Medical Research and Materiel Command (USAMRMC)/Telemedicine and Advanced Technology Research Center (TATRC). In 2003, the Department of Defense and the Armed Forces Epidemiological Board identified musculoskeletal injury prevention research as a warranted focus. As such, the overall objectives of this research project are to reduce the incidence of unintentional injury and enhance military readiness, which will ultimately result in decreased time lost due to disability, personnel attrition, and the financial burden associated with medical expenses and disability compensation. This research approach includes performing 101st Airborne/Air Assault Soldier-specific task and demand analyses for the purposes of identifying the operational and training-related tasks during which musculoskeletal injuries occur. These data will be used to create laboratory models to determine suboptimal parameters that increase the risk of training and tactical injuries while reducing the capacity for peak operating efficiency. This project will provide immediate and tangible deliverables that will enhance the Soldiers' war time deployment preparation. Additionally, long term solutions for optimizing the training needs of the Soldier will be established by providing a sustained human performance enhancement approach that meets the unique demands of the tactical athlete. Unintentional, musculoskeletal and overuse injuries during tactical operations training, combat, and physical training are a principal health concern in the military as the US Armed Forces invest considerable resources per Soldier. Soldiers of the Army 101st Airborne/Air Assault have been described as tactical athletes given the functional demands of operational training and combat. Unintentional, musculoskeletal and overuse injuries have been reported to result from suboptimal biomechanical, musculoskeletal, and physiological characteristics. Given the vigorous demands of tactical operations training and combat, the introduction of preemptive injury prevention and performance enhancement training programs is warranted. The purpose of this multi-phase research initiative is to create a systematic and sustained injury prevention and performance enhancement training program. Specifically, **Phase 1** will identify the current prevalence of injury to Soldiers in the Army 101st and perform task and demand analyses of tactical operations training and physical training. **Phase 2** will identify risk factors for injury and incidence of injury, identify suboptimal biomechanical, musculoskeletal, physiological characteristics relative to the demands of tactical operations training, identify suboptimal nutritional patterns, and develop and validate an injury prevention and performance enhancement training program (Elite Tactical Athlete Training Program). Improvements in the biomechanical, musculoskeletal, and physiological risk factors that are known to contribute to injury will result in a reduction of unintentional, musculoskeletal and overuse injuries and enhanced physiological performance of Soldiers in the Army

101st Airborne. Ultimately, Soldiers in the Army 101st Airborne will demonstrate improved safety and enhanced military readiness which will result in decreased time lost due to disability, personnel attrition, and the financial burden associated with medical expenses and disability compensation.

BODY

Project Overview

Phase 1 Aim 1

To identify the current prevalence of unintentional, musculoskeletal and overuse injury of Soldiers in the Army 101st during tactical operations training

Retrospective data analysis is ongoing. The process to receive data from Blanchfield Army Community Hospital has been identified and the records will be provided. Medical records will be reviewed to determine the prevalence of injuries prior to implementing the Elite Tactical Athlete Training Program.

Phase 1 Aim 2

To perform task and demand analyses of tactical operations training in Soldiers of the Army 101st Airborne and develop protocols for Phase 2-Specific Aim 2 testing

Task analyses were performed for the purpose of identifying specific tactical and physical training activities during which musculoskeletal injuries occur. Task analyses have been completed for the upper extremity, lower extremity, and spine to identify injurious task performed by the 101st Airborne/Air Assault. Examination of the task analysis data directed the development of the laboratory tasks to be 101st Airborne/Air Assault-specific for collection of biomechanical data. Based on the task analyses, laboratory biomechanical procedures were developed to simulate the daily tasks of the 101st Airborne/Air Assault Soldiers.

Demand analyses were performed to identify the metabolic demands of the activities for comparison to physical training to determine if the appropriate energy systems are being trained sufficiently. Demand analyses of tactical operations at Ft Campbell are ongoing, with collection of metabolic data while Soldiers are performing simulated operations and determining the metabolic cost of wearing body armor compared to typical training and during rucksack marching (patrolling maneuvers). Preliminary analysis of metabolic data during a maximal aerobic capacity test when wearing body armor resulted in a 45% reduction in time to exhaustion, and a 15% increase in metabolic cost and 12% increase in heart rate across similar intensities.

Phase 2 Aim 1

To prospectively determine biomechanical, musculoskeletal, and physiological risk factors that contribute to injury in Soldiers of the Army 101st

To date, a total of 250 Soldiers have participated in this research study to evaluate musculoskeletal strength and flexibility, balance, VO2 max, lactate threshold, body composition, movement patterns during functional tasks, and a nutritional screening. Several requests were made by MG Schloesser and COL McBride at the outset to provide immediate and tangible deliverables that will reduce the risk of injury and enhance the training capabilities of the Soldiers of the 101st Airborne/Air Assault as they will be deployed in early fall. As such, today's Soldier, described as a tactical athlete, should possess similar physical characteristics of a well trained athlete if optimal performance is expected. For the purposes of providing immediate tangible data, the tactical athlete's physical data have been benchmarked against a group of well trained athletes of our Pittsburgh lab with a Soldier-specific adjunct injury prevention and performance enhancement program prescribed. Data collection remains ongoing with the plan to continue testing Soldiers of the 101st at an estimated 24 Soldiers/month (total tested 538).

Initial analysis of the sample size compared to an athletic population revealed the following:

STRENGTH: Group average strength deficits were demonstrated in approximately 30% of the Soldiers. More specifically, below minimum threshold scores were displayed by 30% of the Soldiers for shoulder strength, 95% for knee strength, 40% for hip strength, 49% for ankle strength, and 33% for torso strength. Lack of strength can significantly impair joint stability. Lack of flexibility, in particular in the hamstrings and calf, can predispose an individual to musculotendinous injury.

FLEXIBILITY: Group average flexibility was within normal limits, however significant deficits were noted in the hamstrings and calf musculature with 65% and 37% below threshold, respectively.

BALANCE: Group average balance was within normal limits, however deficits were noted in 35% for eyes open and 26% for eyes closed balance.

PHYSIOLOGICAL: Group average body fat was high with 75% above threshold, and a range of 60-100% above threshold when separated by age. Anaerobic peak power and anaerobic mean power were 60% and 75% below threshold, respectively. VO2 max and lactate threshold were 82% and 67% below threshold, respectively. A subset comparison of the 159 Soldiers data to threshold data revealed between 52-91% are outside the normal range for the physiological variables.

BIOMECHANICS: Lower extremity biomechanics during landings were studied as this activity is associated with a high number of musculoskeletal injuries. Upon landing, 20% of the Soldiers demonstrated decreased hip flexion which reduces the efficiency of the strong hip musculature to absorb joint forces. Knee flexion during landing was within normal limits, however 60% landed with a valgus knee position and high vertical ground reaction forces, both of which may ultimately lead to ligamentous sprain and potential rupture.

NUTRITION: Carbohydrate intake was below the recommended value for 85% of the Soldiers while protein intake was below the recommended value for 69% of the Soldiers. Fat intake was high in 70% of the Soldiers. The current nutritional intake indicates a deficit in carbohydrates and protein and excess fat consumption. Adequate energy yielding carbohydrates are necessary for recovery which protein is necessary for tissue recovery and regeneration.

INJURY DATA: Data collection remains ongoing. See comments form Phase 1 Aim 1.

Phase 2 Aim 2

To determine suboptimal physiological characteristics relative to demands of tactical operations training

Data collection remains ongoing.

Phase 2 Aim 3

To develop and validate an injury prevention and performance enhancement training program

Data collection remains ongoing. The Elite Tactical Athlete Training Program has been developed. It is now being validated to determine the effectiveness of newly developed training regimes on a subset of soldiers in the pre-deployment training phase. A second trial will be conducted to determine the efficacy to modify the presumed risk factors based on a subset of soldiers in the "set phase" of training.

KEY RESEARCH ACCOMPLISHMENTS

- Strength deficits identified in approximately 30% of tested Soldiers
- Overall good flexibility identified in tested Soldiers, deficits in hamstrings and calf muscles, known to contribute to injury
- Balance deficits identified in 26% of tested Soldiers
- Approximately 75% of Soldiers possess excessive body fat, considerable health concerns, injury predisposition, and poor performance associated with excess body fat
- Decreased anaerobic and aerobic capacity
- Subset of 159 soldiers demonstrated poor physiological characteristics compared to threshold data

- Increased knee forces and altered landing positions may contribute to lower extremity joint injury
- Carbohydrate and protein intake below recommended values, fat intake excessive

REPORTABLE OUTCOMES

Abstracts

The Relationship among Body Composition, Anaerobic Power, Lactate Threshold and Maximal Oxygen Consumption in Male Soldiers- 2008 National Athletic Trainers' Association

Kinematic adaptations with interceptor body armor in Soldiers of the Army 101st- 2008 National Athletic Trainers' Association

Differences in Knee Kinematics and Vertical Ground Reaction Forces in Air Assault Soldiers Performing Two-Legged Drop Landings with and without Visual Input- Submitted 2009 American College of Sports Medicine

Accuracy of APFT to predict optimal readiness when compared to a battery of physiological and musculoskeletal characteristics- Submitted 2009 American College of Sports Medicine

Effects of body composition on performance in healthy military personnel- Submitted 2009 American College of Sports Medicine

Manuscripts

Not applicable

Grant Submissions

FY 08 CDMRP DRMRP ATTDA: A comprehensive health promotion and nutrition plan to prevent co-morbidities secondary to blast injuries (Pending)

FY 08 CDMRP: A Comprehensive Health Promotion and Weight Management Initiative to Improve the Health, Fitness, and Quality of Life of Military Personnel (Pending)

CONCLUSION

Data collection remains ongoing for both laboratory testing and prospective analysis of injury incidence to determine which biomechanical, musculoskeletal, and physiological characteristics may contribute to injury.

Preliminary analysis of data indicates several areas of training that should be implemented to optimize performance. Also, a large variability was demonstrated for many of the variables. Given the range of testing results, it is likely that PT may need to be modified to include training amongst soldiers of similar performance levels.

Nutritional intake is poor and does not support the daily training activities performed by the Soldiers. Modification of nutrition with educational support should be provided to ensure optimal fueling of the Soldier, prompt muscle recovery following workouts, and maintaining health and wellness.

REFERENCES

Not applicable

APPENDICES

Not applicable

SUPPORTING DATA

Not applicable